COST AND PERFORMANCE REPORT

In Situ Conductive Heating at the
Confidential Chemical Manufacturing Facility
Portland, IN

June 2003

SITE INFORMATION

IDENTIFYING INFORMATION

Site Name: Confidential Chemical Manufacturing Facility
Location: Portland, Indiana
Regulatory Context: Voluntary cleanup
Technology: In Situ Conductive Heating
Scale: Full-scale

TECHNOLOGY APPLICATION [1,2]

Period of Operation: July to December 1997

Type/Quantity of Material Treated During Application: Source zone (unsaturated) - Estimated area treated was 5,000 cubic yards or 6,500 tons of soil

BACKGROUND [1,2]

The 16 acre site is a chemical manufacturing facility located in the southern portion of Portland, Indiana, southeast of the Salmonie River. The site has the operated since 1886, first as a lumber yard, then for wheel manufacturing. From 1937 to the mid-1970's, the site was used for the manufacture of hard rubber products used in automobiles and then for the manufacture of plastic exterior automobile parts. The site has four buildings: the north plant building, a parts storage building, a paint storage building, and a former boiler house. According to the plant manager, the north plant building is currently being used part time for the reworking of automotive parts.

Sampling conducted as part of a due diligence assessment in June 1994 showed the presence of volatile organic compounds (VOCs) in soil and groundwater. Results of additional investigations performed from July 1995 to February 1996 confirmed the presence of VOCs in subsurface soils in two areas identified as GP-31, adjacent to the loading dock at the north building, and GP-28, about 300 feet (ft). southeast of the loading dock. Results of groundwater sampling conducted in August 1995 showed that VOCs were not present in the sand and gravel aquifer beneath the site at levels higher than the cleanup goals.

CONTACTS

Technology System Vendor:
Ralph Baker, Ph.D.
CEO and Technology Manager
TerraTherm, Inc.
356 Broad St.
Fitchburg, MA 01420
E-mail: rbaker@terratherm.com

State Contact:
Mary Beth Tuohy
Assistant Commissioner
Indiana Department of Environmental Management
Office of Environmental Response
P.O. Box 6015
Indianapolis, IN 46206

MATRIX DESCRIPTION

MATRIX AND CONTAMINANT IDENTIFICATION [1,2]

Type of Media Treated With Technology System: Source zone (unsaturated)

Primary Contaminant Groups: Chlorinated Solvents

SITE HYDROGEOLOGY AND EXTENT OF CONTAMINATION [1,2]

Figure 1 is a cross-section of the site. The site geology included fill, a combination of sand, clayey sand and construction debris, to a depth of about 7 ft. Till consisting of moist, damp, silty clay extended to a depth ranging from 18 to 19 ft, with sand seams running through the till. Below the till was a sand and gravel layer extending to a depth of 30 ft and consisting of poorly sorted sand. Groundwater was encountered in the sand and gravel layer at depths of 22-25 ft. The estimated hydraulic conductivity of this zone was 10^{-8} cm/sec.

Contamination in GP-31 covered an area of 150 ft by 50 ft to a depth of 18 ft and primarily consisted of trichloroethene (TCE) and tetrachloroethene (PCE), detected at levels up to 79 mg/kg and 3,500 mg/kg, respectively. The high concentration of PCE in the GP-31 area suggested the presence of DNAPL. The contamination in the GP-28 area covered an area of 30 ft by 20 ft to a depth of 11 ft and primarily consisted of 1,1-dichloroethene (DCE), detected at a maximum concentration of 0.65 mg/kg.

Figure 1. Representative Cross Section of Treated Subsurface [1]

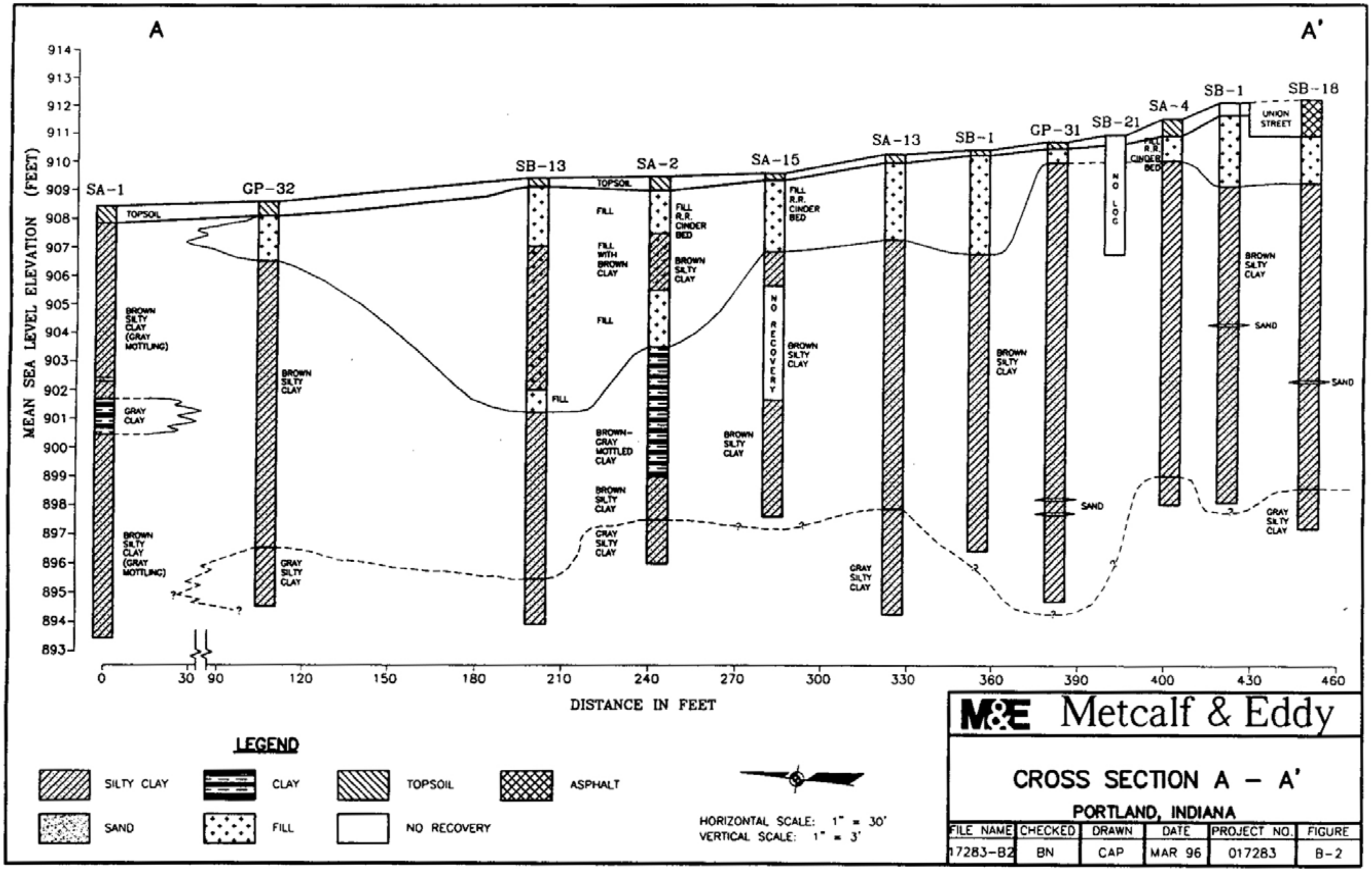


Table 1 lists the matrix characteristics affecting treatment cost or performance for this application.

Table 1. Matrix Characteristics [1]

Parameter	Value
Soil Classification	Heterogenous zones of clay, sand, gravel, and debris fill
Clay Content and/or Particle Size Distribution	Fill consisting of sand, clayey sand, gravel, and construction debris from 1 to 7 ft bgs. Silty clay with discontinuous sand seams containing perched groundwater beneath the fill to 18 to 19 ft bgs. Sand and gravel from the silty clay to 30 ft bgs.
Depth to Groundwater	Aquifer located 22 to 25 ft bgs, perched groundwater in sand seams at shallower depths
Hydraulic conductivity	10^{-8} cm/sec in the silty clay layer. Information not available for the fill and sand and gravel layers.
Porosity	Not available
Air Permeability	Not available
Presence of NAPLs	Suggested presence of DNAPL
Moisture content	Not available
Total organic carbon	Not available

TECHNOLOGY SYSTEM DESCRIPTION

TREATMENT TECHNOLOGY

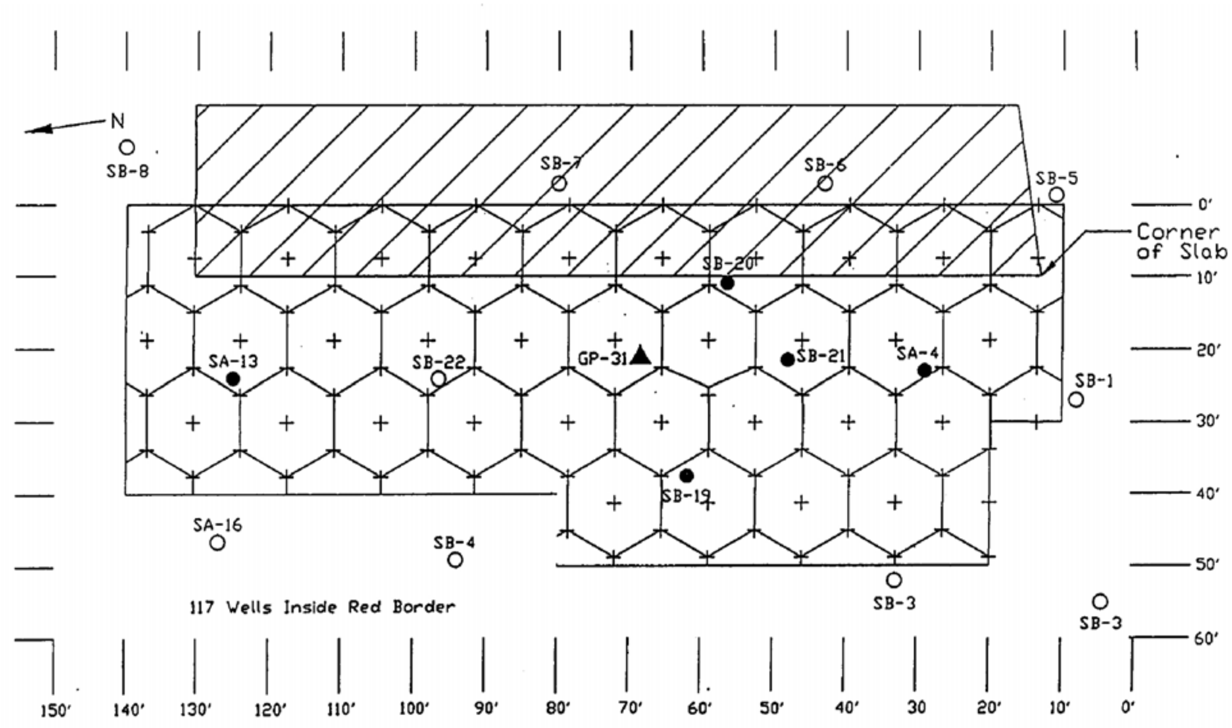
In situ conductive heating (In Situ Thermal Desorption™)

TREATMENT SYSTEM DESCRIPTION AND OPERATION [1,2]

The in situ conductive heating system used at this site consisted of three free-standing trailers - a control trailer containing instrumentation, an electrical substation providing power for the system (1 to 1.5 MW), and an off gas vapor treatment trailer containing a flameless thermal oxidizer. The heater/vacuum wells were operated at 1,400 - 1,600 °F. Heat was injected into the subsurface and soil gas was extracted under a vacuum.

For area GP-31, a total of 130 heater/vacuum wells were installed on 7.5 foot triangular spacing to a depth of 19 ft, as shown in Figure 2. Twenty-five of these wells were drilled through the concrete loading dock. For Area GP-28, 18 heater/vacuum wells were installed on 7.5 foot triangular spacing to depths of 12 ft, with approximately 1 well per 50 square ft of surface area treated.

Figure 2. Heater/Vacuum Well Layout for Loading Dock Area[1] [2]



1 Circles and triangles that are filled in indicate locations where the PCE concentrations exceeded the cleanup goals prior to treatment. Open circles indicate locations where the PCE concentrations were below the cleanup goals prior to treatment. The "+" symbols indicate the locations of the heater/vacuum wells.

The well was 4.5 inches in diameter with sand packed liners in 6 inch augured holes. The heaters were extended 3 ft below the deepest contaminated layer. The surface area between wells was covered by an impermeable silicone rubber sheet to prevent fugitive emissions. A thermally insulated mat was used to minimize surface heat loss. During installation, the thick fill in the northernmost part of the site was found to be saturated with water originating from a railroad gravel bed. After pumping failed to dry the area, a 5 ft deep dewatering trench was installed.

Subsurface temperature in the treatment zone was monitored using 91 hollow logging tubes placed in the areas expected to be the coldest locations in each triangular heater pattern, which were at the centroids of the triangles. The maximum soil temperature achieved in the treatment area at a depth of 13 ft ranged from 212°F to 500°F. During operation, recharge of water in the wet till region prevented temperatures in this area from rising above 212°F; however, all temperatures in the area were at least as high as the boiling of water.

Off-gases were treated with an 1800 scfm flameless thermal oxidizer with an operating temperature range of 1800 - 1900°F. Off-gases were cooled by a heat exchanger, then passed through a carbon absorption bed. Off-gases were monitored for hydrogen chloride, which was used as an indicator of the decomposition of chlorinated solvents.

TIMELINE [1,2]

- 1994 - 1996 — Site investigations performed
- July - Dec 1997 — Remediation performed
- Date not provided — Indiana EPA issues a no further action letter

TECHNOLOGY SYSTEM PERFORMANCE

PERFORMANCE OBJECTIVES [1,2]

Cleanup goals were based on the Indiana Department of Environmental Management (IDEM) Tier II Clean-Up Goals for Industrial Land Use. The soil cleanup goals were 8 mg/kg for PCE, 25 mg/kg for TCE, and 0.080 mg/kg for 1,1-DCE.

TREATMENT PERFORMANCE [1,2]

Prior to discontinuing heating, about 50 soil samples were collected from the coldest locations (centroids) furthest from each heater well and analyzed for VOCs. The results from the soil samples, along with data from temperature profiles and HCl monitoring, were used to determine whether additional heating was required. Based on the results, heating was discontinued in December 1997. Before confirmation sampling was conducted, soil temperatures were monitored for about 6 months as the soil within the treatment area cooled to below 100°F. Confirmation sampling was conducted in accordance with the random sampling methodology required by the IDEM Voluntary Remedial Program Resource Guide. With the exception of GP-31, SA-13, and SA-4, a 1 foot sampling interval was used for each confirmatory soil boring location. Sample intervals for borings GP-31, SA-13, and SA-4 correspond to the intervals where the highest concentrations of VOCs were detected in the subsurface soils prior to treatment.

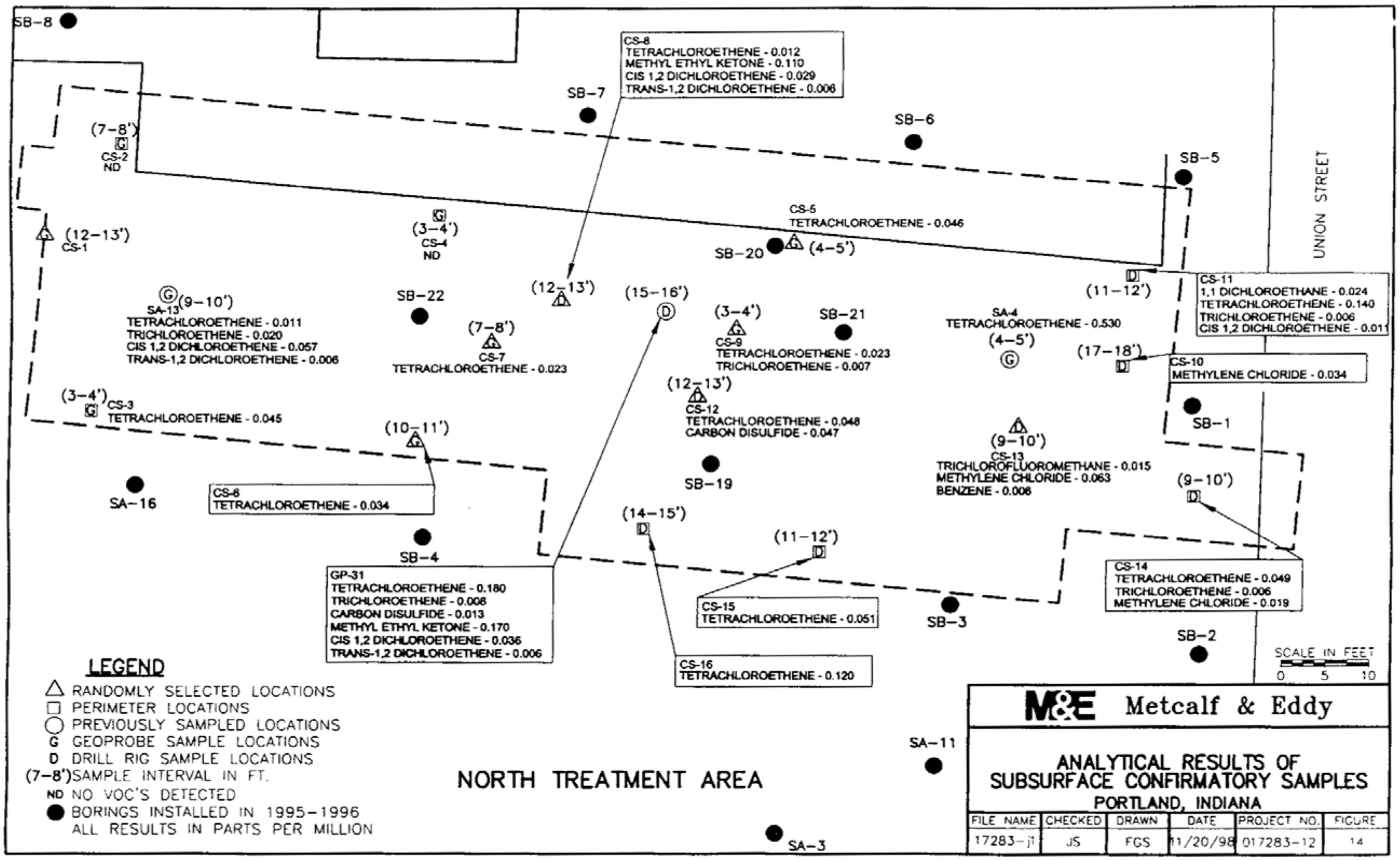
Sampling locations SA-13, GP-31, SA-4, SB-20, SB-19, and CS-12 had relatively higher concentrations of PCE and TCE before treatment, at the depths shown in Table 2. This table shows that the concentrations of PCE and TCE in the soil at these locations was less than the cleanup goals after treatment. Figure 3 shows the after-treatment results for confirmatory samples across area GP-31. This figure shows that contamination had not spread outside the treatment area. No confirmation samples were available for the smaller, DCE contaminated zone (area GP-28).

Table 2. Comparison of Selected Pre-Heating and Post-Heating Contaminant Concentrations [1]

Sampling Location	Depth (ft)	Contaminant Concentration (mg/kg)	
		Before Treatment	After Treatment (Cleanup goal - PCE 8; TCE 25)
SA 13	9-10	PCE = 3,500 TCE = 79	PCE = 0.011 TCE = 0.020
GP 31	15-16	PCE = 570 TCE = NA	PCE = 0.18 TCE = 0.008
SA 4	4-5	PCE = 23 TCE = 0.25	PCE = 0.530 TCE = ND
SB 20	4-5	PCE = 2.9 TCE = 0.67	PCE = 0.046 TCE = ND
SB 19 CS 12 (8 ft away)	12-14	PCE = 76 TCE = 1.6	PCE = 0.048 TCE = ND

ND - non-detect (detection limits not provided)

Figure 3. Subsurface Confirmatory Samples [1]



COST OF THE TECHNOLOGY SYSTEM

COST DATA

Cost data were not provided for this application.

OBSERVATIONS AND LESSONS LEARNED

OBSERVATIONS AND LESSONS LEARNED

In situ conductive heating treated 6,500 tons of soil contaminated with chlorinated solvents to below cleanup goals in six months.

During the installation stage, perched water was encountered in the thick fill in the northernmost portion of the site originating from railroad gravel bed. According to the vendor, after weeks of pumping failed to dry the area, a 5 foot deep dewatering trench was installed north of the last row of wells to reduce water inflow. However, during treatment system operation, water recharge occurred in this area. According to the vendor, while the soil temperature in this area reached the boiling point of water, allowing for remediation of the contaminants, the presence of the water prevented the soil temperatures in this area from exceeding 212°F.

To prevent migration of contaminants out of the treatment zone, and ensure effective heating of the entire treatment zone, heaters/vacuum wells were installed 3 ft below the deepest contaminated layer and at least one grid of wells was installed beyond the contaminant zone. This resulted in an increase in the size of the treatment area.

REFERENCES

1. Vinegar, Harold J., G.L. Stegemeier, F.G. Carl, J.D. Stevenson, and R.J. Dudley. 1999. "In Situ Thermal Desorption of Soils Impacted with Chlorinated Solvents." Proceedings of the Annual Meetings of the Air and Waste Management Association, Paper No. 99-450.

2. Baker, R.S., H.J. Vinegar, and G.L. Stegemeier. 1999. "Use of In-Situ Thermal Conduction Heating to Enhance Soil Vapor Extraction." Pp. 39-57. In: P.T. Kostecki, E.J. Calabrese, and M. Bonazountas (eds.). Contaminated Soils, Volume 4. Amherst Scientific Publishers, Amherst, MA.

3. Stegemeier, G.L., and Vinegar, H.J. 2001. "Thermal Conduction Heating for In-Situ Thermal Desorption of Soils." Ch. 4.6, pp. 1-37. In: Chang H. Oh (Ed.). Hazardous and Radioactive Waste Treatment Technologies Handbook, CRC Press, Boca Raton, FL.